α_s determination by the DELPHI Collaboration

Presented by R. Zitoun

LPNHE, Universités Paris VI et VII, Tour 33 RdC, 4 place Jussieu, 75252 Paris CEDEX 05, France

Abstract

We briefly report on two different measurements of the strong coupling constant α_s from a comparison of the DELPHI data on the Z^0 peak at LEP to second order predictions of perturbative QCD. The study of multijet event rates yields $\alpha_s(M_Z^2) = 0.114 \pm 0.003[stat] \pm 0.004[syst] \pm 0.012[theo]$ and the study of energy-energy correlations yields $\alpha_s(M_Z^2) = 0.106 \pm 0.003[stat] \pm 0.003[syst]^{+0.003}_{-0.000}[theo]$.

1 Introduction

This paper gives a short account of the results [1,2] obtained by the DELPHI collaboration concerning α_s, the QCD coupling constant, and/or $\Lambda \equiv \Lambda_{\overline{MS}}^{(5)}$, the QCD scale parameter related by

$$\alpha_s(\mu^2) = \frac{12\pi}{b_0 L}\left[1 - \frac{b_1 \ln(L)}{b_0^2 L}\right] \qquad (1)$$

with $b_0 = 33 - 2N_f, b_1 = 918 - 114N_f$ and $L = \ln(\mu^2/\Lambda_{\overline{MS}}^{(N_f)})$; the number of flavours N_f is taken to be 5 at LEP energy.

Two different observables have been used to extract the results from the data :

- the jet production rates : the n-jet prodution rate is defined as $R_n(y) = \sigma_n(y)/\sigma_t$ where σ_n is the cross-section for producing an n-jet event and σ_t is the total hadronic cross-section. The jet production rates depend on the jet clusterisation algorithm and on the cutoff parameter y. It is in fact the y-dependance of R_n which is used to extract the QCD parameters.
- the angular distribution in the energy-energy correlation (EEC) is the histogram of the angles χ between any two particles within an event, weighted by the product of the fraction of energy of these particles, i.e. $E_i E_j / E_{tot}^2$. Such a distribution has two peaks around $\chi = 0$ or π corresponding to the two main jets, the one near $\chi = \pi$ being distorted by the presence of secondary jets. It is an infrared safe quantity which do not use any recombination scheme. The asymmetry of this distribution is our second observable.

The experimental data have been in each case compared to QCD predictions. The jet production rate analysis has been done using the second order matrix elements of Kramer and Lampe [3] (KL'). The angular distribution of EEC has been compared to Ellis, Ross and Terrano [4] second order matrix elements. In both cases, the partons have been fragmentated using the string model as implemented in the JETSET package [5].

The dependence on fragmentation models, recombination scheme, energy scale, etc. have been studied in detail.

2 Data

The DELPHI detector has been described at this conference ; details can be found elsewhere [6]. Only charged tracks have been considered in this study, their momentum and energy being measured by the tracking devices (Inner and Outer Detectors and TPC) and assuming the pion mass.

A good track has been defined to have : an impact parameter at the nominal primary vertex $r <$ 5cm and $|z|$ <10cm ; a momentum>0.1 GeV/c ; a polar angle between 25 and 155° ; a track length>50cm.

A good hadronic event has been defined to have at least 5 tracks with momentum>0.2GeV/c ; a charged energy in each hemisphere>3 GeV/c ; a missing momentum<30 GeV.

Data from the 1989 run only have been used for this study. They amount to 4990 events. In addition to these events, 1727 events were recorded in the same run with the magnet operated at 0.7 T instead of the nominal 1.2 T. These data have been used for systematic error study. Contamination from beam gas and $\gamma\gamma$ interactions has been estimated to less than 0.1% and from τ pairs to 0.2%.

3 Jet production rates

Jets have been reconstructed from charged tracks by using the JADE clustering algorithm [7]. Their prodution rates have been corrected for detector imperfections, kinematical cuts, QED corrections and for small fragmentation effects with various Monte Carlo simulations. They are shown on Fig.1.

These data have been fitted to the KL' expressions in the range $0.05 < y_c < 0.25$ in which the 4-jet rate

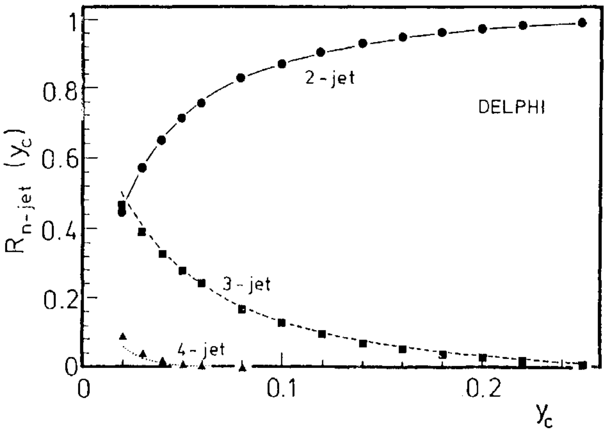

Figure 1: Experimental jet rates as a function of the cutoff y_c. The curves show the result of the fit for $0.05 < y_c < 0.2$.

is negligible (in fact the differential rates D_n have been used to simplify the statistical treatment). Setting the normalisation scale to Q^2 yields $\Lambda = 180^{+33}_{-30}$ MeV or $\alpha_s(M_Z^2) = .114 \pm 0.003$. Systematic error have been evaluated by varying the correction factors ; it amounts to $^{+43}_{-38}$ MeV on Λ and ± 0.004 on α_s. Other recombination schemes and QCD calculations have been used. They lead to quote a theoretical error on α_s of 0.012.

Finally, fits were performed on a y_c range extending down to 0.02 where the 4-jet rate is no longer neglegible. Satisfactory fits were obtained only for a scale fM_Z^2 with f around 0.001. This might be an effect of the unknown third order QCD terms.

4 Energy-energy correlation

After having corrected the data as before, they have been compared to Monte Carlo data generated from second order QCD expressions as implemented in JETSET 7.2 [5]. In this program version, the scale factor is set to f =0.002, a value which has been shown to reproduce well several pieces of data. The comparison was done in particular on the asymmetry in EEC (Fig. 2), namely

$$AEEC(\chi) = EEC(180^\circ - \chi) - EEC(\chi) \quad .$$

The resulting value of Λ is 104^{+25}_{-20} MeV ; it corresponds to a nice agreement with the data. The above statistical errors have been obtained by splitting the data into 9 independent samples. Several systematic effects have been studied, including changes in the fragmentation parameters or models. They imply a systematic error of $^{+25}_{-20}$ MeV on Λ. Finally, varying the scale factor up to $f = 1$ makes Λ vary by 30 MeV ; this variation has been taken as a theoretical

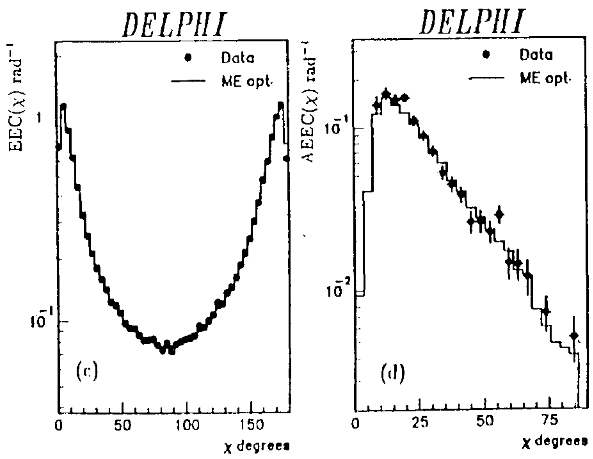

Figure 2: Corrected EEC and AEEC compared to the result of the fit to second order matrix element expressions.

error. From the above value of Λ, we derive

$$\alpha_s(M_Z^2) = 0.106 \pm 0.003[stat] \pm 0.003[syst]^{+0.003}_{-0.000}[theo]$$

5 Conclusion

The DELPHI collaboration has performed two independent determinations of $\alpha_s(M_Z^2)$. From jet rates and EEC, we obtain respectively :

$$\alpha_s(M_Z^2) = 0.114 \pm 0.003[stat] \pm 0.004[syst] \pm 0.012[theo]$$
$$\alpha_s(M_Z^2) = 0.106 \pm 0.003[stat] \pm 0.003[syst]^{+0.003}_{-0.000}[theo].$$

The results agree with the determinations of $\alpha_s(M_Z^2)$ from other LEP collaborations presented at this conference.

References

[1] P. Abreu et al. (DELPHI Coll.) Phys. Lett. 247B (1990) 167.

[2] P. Abreu et al. (DELPHI Coll.) Energy-energy correlations in hadronic final states from Z^0 decays, CERN-PPE/90-122, to appear in Phys. Lett. B.

[3] G. Kramer and B. Lampe, Fortschr. Phys., 37 (1989) 161.

[4] R.K. Ellis, D.A. Ross and E.A. Terrano, Phys. Rev. Lett. 45 (1980) 1225 ; Nucl. Phys. B178 (1981) 421.

[5] T. Sjostrand and M. Bengtsson, Comp. Phys. Comm. 43 (1987) 367 and references therein.

[6] P. Aarnio et al., The DELPHI detector at LEP, CERN/EF 90-5 and CERN-PPE/90-128, submitted to Nucl. Instrum. Methods.

[7] W. Bartel et al., (JADE coll.) Z.Phys.C, 33 (1986) 23.